LIBRARY
OF THE
MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

HD28
.M414
no.213-66

WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

THE MARKETING EXECUTIVE AND MANAGEMENT INFORMATION SYSTEMS

213-66

Arnold E. Amstutz

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139

THE MARKETING EXECUTIVE AND MANAGEMENT INFORMATION SYSTEMS

213-66

Arnold E. Amstutz

HD28
.M414
no. 213-66

RECEIVED
SEP 26 1966
M. I. T. LIBRARIES

THE MARKETING EXECUTIVE AND MANAGEMENT INFORMATION SYSTEMS*

Arnold E. Amstutz

Introduction

This paper is concerned with the present state of the art in market oriented management information and control systems and the impact of these systems on policy and operating management. As such, this discussion will be narrowly focused. Normative questions of what management should or should not expect or obtain from an information system will not be considered.

Objectives

The two major objectives of this paper may be simply stated as:

1. To identify relevant characteristics of successfully implemented management information and control systems.
2. To evaluate the impact of representative systems on the managements they were designed to serve.

The Process of System Evolution

It is seldom possible to impose a pre-packaged information system on a management group. There are no generalized management information systems. Each company's management has unique information requirements; a unique perspective on the environment within and outside of their firm; unique priorities; and a style of management which is the unique product of the particular personalities making up the management group. Successful system development is a matter of evolution. Effective management systems evolve over time as management and system specialists learn to communicate, structure problems, and achieve a joint focus on increasingly broad information needs.

About the Author. Arnold E. Amstutz is Assistant Professor of Management at the Sloan School of Management, Massachusetts Institute of Technology. He is engaged in research and consulting work relating to applications of computer technology in marketing management and is the author of several articles in this area.

*A talk presented to the American Marketing Association Meeting in Bloomington, Indiana, September 1, 1966.

The process of designing and developing a management information system to meet the requirements of a particular management's decision style makes significant demands on management time and thought. If the resulting product is to be compatible with management's perspective, priorities, and systems of measures, management's models of the decision environment must be made explicit and used as the basis of system design. In addition, management must evaluate the implications of alternative system structures in terms of criteria which only they can supply. Intelligent choice between alternatives must be based on management understanding of the implications of available structures. In order to achieve understanding the manager must take the time necessary to become familiar with the management implication of basic system design concepts.

Just as there is no single generic management information system, there is no single payoff associated with all systems. It may be argued, in fact, that the benefits gained from a particular system are largely determined by the demands which management makes of the system and the capabilities established in the course of system design.

Dimensions of Evaluation

No two managements have the same information needs. As indicated earlier, the characteristics of systems developed for different managements are as different as the managers' personalities, the problems they face, and their approach to the complex art of management. Despite these differences it is possible to identify sets of dimensions for use in evaluating specific systems and isolating similarities and differences between systems. Figures 1 and 2 illustrate four such dimensions.

Information Recency

The first dimension, information recency, refers to the time lapse between occurrence of an event in the environment and inclusion of data describing that

event in the system. This may range from several weeks in the case of certain market developments to a few hours or minutes for automated inventory control.

Information Aggregation

The second dimension, information aggregation, describes the detail with which information is maintained in system data files. Inventory control systems in which information regarding product components or sub-assemblies is maintained at the item level are representative of relatively disaggregated (micro) data maintenance while industry market share statistics of the type developed through trade associations are representative of highly aggregate (macro) measures.

As illustrated in Figure 1, there is normally a relationship between level of aggregation and the time delay involved in incorporating associated data in the system.

Analytical Sophistication

The third dimension, analytical sophistication, refers to the sophistication of models or structure encompassed by the system. As illustrated in Figure 2, the lowest level of analytical sophistication is that required to identify a particular file and record. At this level it is only necessary for the computer to retrieve the specified record and display the information which it contains. The second level of analytic sophistication involves aggregation -- gathering together numbers from within one or more records to produce a total or sub-total. At the third level the computer may be programmed to perform arithmetic averaging or to compute differences. The fourth level, logical analysis, introduces the use of classification schemes through which various types of data are aggregated within sub-sets or conditionally segmented.

At the fifth level of analytical sophistication statistical analyses may be employed to develop extrapolations from historic data, statistical best estimates, analyses of variance, or trend estimates.

The term learning is used in Figure 2 to indicate adaptive system processes through which the computer is programmed to modify parameter values or model

structures on the basis of experience (data inputs received) over time.

At the most advanced level of analytic sophistication, simulation, models on which the system is based constitute an artificial environment paralleling real world markets referenced by the information systems. The managers' perception of the environment has been explicitly modeled to a sufficient extent and detail to justify the assumption that the models making up the simulated environment duplicate in all relevant aspects the response pattern of the real world environment monitored through the information system. Inputs to the information system are directly related to process variables in the simulation models. At this stage in development the system provides management with the capability of testing proposed policy and strategies in the simulated environment; choosing between alternatives on the basis of resulting output; implementing the policies in the real world environment; and evaluating the effectiveness of implemented plans through the information system. The manager references the simulated environment to ask "What if"? and the information system monitoring the real world environment to determine "What is"?.

Computer Authority

The final dimensions of system evaluation, authority delegated to the computer, is closely associated with the system's analytic sophistication. Management is more willing to delegate authority to sophisticated systems and, conversely, as management places greater demands on an information system, a greater level of analytic sophistication must be embodied in the system structure.

At the lowest level management may delegate to the computer authority to retrieve information from specified records and files -- entrust to the computer system processes associated with identification and retrieval. Once a retrieval capability has been established it is usually a short step to the next level of computer authority. Recognizing that the computer has access to all records in the file, management concludes that while the computer is "looking at" the contents of each record it might as well check the reasonableness of record

content to insure against gross clerical errors. At this stage the computer is delegated a supervisory function checking on human personnel responsible for input.

As management comes to accept computer review for purposes of error detection, they normally begin to think in terms of other functions which the computer could perform "while looking at all those records". It follows quite naturally to have the computer perform additional analyses on records which it is reviewing and refer for further review and action situations meeting criteria established by management.

Management frequently finds that certain classes of monitor output are consistently subjected to additional analyses to determine whether or not action is warranted. In such situations it is natural to suggest that the computer be programmed to perform the additional calculations in order to add a recommendation for action to the monitor report.

As management gains experience with computer based recommendations they may find that in most situations they are able to implement computer recommendations without further investigation. Criteria may be modified to isolate non-typical cases requiring additional review. The computer is then given authority to take action on the remaining cases in which its recommendations are a valid basis for action.

The hierarchy of Figure 2 suggests that delegation of authority to predict involves a higher level of management dependence on the computer than authority to act. While the models on which the computer bases its action normally involve prediction, the potential impact of computer based prediction is often greater than computer action. Computer originated actions may adversely affect the firm's position at a point in time. However, actions relate to the operating sphere while predictions are the basis for planning. Thus, inaccurate prediction may have a damaging effect on the firm's activities for months or

years while erroneous actions can be corrected in days or weeks.

The chance for successful computer based prediction is ironically reduced by the very nature of management-computer interaction. Since predictions are often based on relatively sophisticated models, management is frequently hesitant to accept the computer's prognostication until they have gained experience with the system and had an opportunity to "see how it does". With the passage of time management's satisfaction with predictions which are verified by subsequent experience increases. However, as time passes the modeled environment may change -- the original models may become less and less applicable. Finally at that point when management is ready to take action based on the computer's predictions the models may be completely outdated and no longer accurately represent the decision environment. When this happens the stage is set for disillusionment or worse. It is considerations such as these which argue strongly for management involvement in the system design process, familiarity with system structure, and understanding of models on which system decisions and predictions are based.

Characteristics of Successful Systems

While specific functions performed by successful systems are as varied as the managements to which they contribute, four common characteristics of successful systems or perhaps more correctly the environment in which successful systems operate, can be noted.

1. The system is founded on management's conception of the decision environment.
2. The user-manager understands the system structure.
3. The system is based on disaggregated data files.
4. System development has proceeded to increasing levels of sophistication through a process of gradual evolution.

Management's Conception of the Environment

If a system is to provide meaningful information to a particular management it must reflect that management's priorities and provide information of a type and in a form which is assimilable in the context of existing management decision processes. In most situations this requirement specifies that the information must be selectively generated -- management is simply incapable of assimilating reams of paper -- and must be based on accepted measures -- output must relate directly to management conceptions of processes occurring in the monitored environment.

In order to meet this requirement an information system must be based on explicit models of the environment provided by management. In most instances management's initial system definition is stated in qualitative "business terms". Before meaningful specifications can be established this frequently vague and ambiguous initial statement must be refined and restated in explicit terms. Factors considered relevant in the decision environment must be defined and differentiated from those to be excluded.

Management Understanding

Management must be involved in this quantitative specification of system boundaries. They must understand and accept the conceptual structuring of system requirements in terms sufficiently explicit to define the measures and analytical procedures to be encompassed by the system. If this level of communication is not achieved, it may be impossible for those concerned with system formulation to develop a system which will be used.

But, it may be argued, this means involving management in wholly unacceptable detail. "Management is appropriately concerned with the big picture. It is unrealistic to expect them to become involved in questions of measurement." The response to this objection is to reiterate the area of eventual system application -- matters of company policy. It is difficult to

conceive of a point in the decision-making process at which involvement is more warranted than in insuring precise description of the decision structure -- unambiguous system specification.

The process of explication often uncovers the not altogether surprising fact that various members of management have different implicit conceptual models of the decision environment. Making these models explicit removes the ambiguities which permit vague words to mean different things to different people. Alternative representations are proposed and necessitate the creation and validation or rejection of more than one model.

As with any other specialized tool the information system must be carefully designed to meet the specific requirement of the craftsman who will use it and the user must understand its function and capabilities. There is no such thing as a generalized information system. It is difficult to conceive of a more specialized and highly segmented market than that for management information. The products which have gained acceptance in this market have been one of a kind special orders produced with careful attention to the needs and preferences of the ultimate user.

The Disaggregated Data File

At the heart of every successful information system is a disaggregated data file -- a file in which information is maintained in detailed time sequence as it is generated. As new inputs are received they are maintained along with existing data rather than replacing or being combined with existing information. New data are not combined with old to form sums, averages, or aggregate distributions. As a result, structural biasing through aggregation which destroys much information value is avoided.

Figure 3 illustrates the concept of a disaggregated data file based on data from invoice records. The disaggregated customer file contains the name, address, demographic, and financial experience records for particular consumers. Each transaction is recorded in chronological order in the file so that at any

point in time it is possible to recreate the company's interactions with each consumer over time. In a similar manner the product file is organized to reference a detailed chronological sales record.

The importance of a disaggregated file rests in part on the evolutionary process through which successful information systems develop. Although an information system may initially be designed to perform strict limited functions, as management gains experience these functions change. If data are initially structured (aggregated) to meet first stage requirements, later modification of system functions necessitate costly file reorganization.

The existence of a disaggregated file facilitates system evolution. Given access to detailed chronological data the manager is able to test new concepts and ideas against historical data asking the question "what would have happened if we had used these criteria in our monitor system -- performed this analysis to isolate actionable situations?". In the first stages of system development it is simply impossible to anticipate the direction of later advancement. Aggregate data files may preclude highly profitable system modification. The disaggregated data file provides the flexibility which is the prerequisite of intelligent system evolution.

Design for Evolution

Successful information systems are designed to permit expansion and change. As indicated above, the disaggregated data file is a key element in system flexibility. In addition, data files must be designed to permit expansion. Variable, rather than fixed record length file structures and self-expanding file constructs are basic to the well planned system.

As management gains experience in working with well organized and accessible data they become increasingly interested in and prepared to use more advanced analytical procedures. The system's analytical structure must not preclude this advancement. Programs must be organized to permit experimental use of new

techniques as well as the permanent incorporation of additional capabilities as part of the standard system configuration.

Characteristics of Managers Who Implement Successful Systems

In view of the key role which management plays in the specification and design of information systems, it is not surprising to find that the managers who are successful in developing and using management information and control systems share common attributes which distinguish them from the average administrator.

There is no industry bias in the population of successful information system users. Successful systems have been designed and implemented in consumer and industrial product and service companies as well as financial institutions. The members of this heterogeneous group may, however, be distinguished from their colleagues on the basis of the following characteristics which they share:

1. Belief that corporate growth is limited by their ability to assimilate and act on information.
2. Willingness to consider change.
3. Willingness to become personally involved in explication.
4. Willingness to test preconceptions.
5. Willingness to modify "time proven" procedures.

The managers involved in system development must be interested in making better decisions. They must be sufficiently confident and mature to consider conflicting approaches to a problem and to choose between alternatives on the basis of rational evaluation. They must be willing to give up implicit models with which they have worked for many years if, when made explicit and tested, these models are found lacking.

Over and above the personalities of individual managers, the environment within the company must support a free interchange of ideas. If managers are

unable to separate ideas from men -- if they evaluate the worth of a concept in terms of the title of the individual proposing it -- steering committee sessions will quickly give way to corporate infighting.

Obviously no company has a management which is perfectly objective and devoid of all traces of negative attributes. In final analysis it is a question of the ability of proponents of information system development to promote and implement this concept and management's willingness to engage in this type of activity recognizing the commitment and orientation required for success.

Examples Illustrating Basic Concepts

The remainder of this discussion will be devoted to examples illustrating system concepts associated with the management impact of information systems. We will begin with a relatively simple retrieval system developed for a small electronics company. Using this management environment as an example, the initial impact of a simple retrieval system will be examined. This will be followed by consideration of the impact of system conversion to on-line operation and the introduction of monitor, advisory, and decision making functions. The impact of real time information acquisition and micro-analytic simulation will also be considered.

A Basic Information Retrieval System

In June 1964 I presented a paper to this association describing a basic marketing information system developed for use by a small company introducing a new product to a difficult to define market.[1] I believe this system provides

---

[1] "A Basic Marketing Information System -- A Case Study in the Economical Use of Computerized Management Information Systems", A Talk presented to the American Marketing Association Meeting in Dallas, Texas, June 16, 1964.

a good point of embarkation for our present discussion.

This system was designed to perform two relatively simple but useful functions:

1. Repetitive clerical operations.
2. Data organization.

It was a relatively simple information system first implemented in 1961 by a small company entering a new and undefined market with a product which was totally new in concept and function. Among the most pressing problems faced by the management of this company was to gain as much knowledge as possible about the markets they were entering. Unfortunately, with limited finances, they were not in a position to conduct extensive market research and were forced to promote and sell their product while learning about market response and composition.

Initial sales were generated through media advertising direct to various market segments. Advertising was designed to generate orders and requests for further information. Inquiries sent directly to the company or forwarded by distributors were answered with brochures describing the product line. Products were sold both direct and through distributor-retailer channels. Literature was supplied to retail outlets but since the company wished to encourage retailer forwarding of requests for additional information, it credited retailers with sales made to customers whose inquiries had been forwarded even though the customer might order directly from the company.

The basic justification for this system was its performance of clerical functions including order processing, mail preparation, invoicing and billing, financial record keeping, and warranty maintenance at a lower cost than clerical personnel. The management information and control functions of this system were, in a very real sense, bonuses gained from the system by designing it to keep track of and organize the information which it encountered while performing routine clerical operations.

The system exhibited the prerequisite of success outlined above. It was closely geared to management's concept of the new market environment; management was deeply involved in system design; a disaggregated customer file contained records relating to customers and potential customers with whom the company came in contact; and its structure was highly flexible -- as experience was gained in working with the system management was able to modify and expand its function and scope.

This system falls at the midpoint on the information recency dimension introduced earlier. The average process lag between receipt of information at the company and inclusion in the system was from one to four days. It is important to recognize that this configuration did not involve measures of market activity other than those derived from media received at the company.

Evaluated in terms of level of information aggregation this system falls at the item level. It is based on a detailed disaggregated data file.

From a standpoint of analytic sophistication the system encompasses the first four levels illustrated in Figure 2. Although fundamentally a retrieval system programs used to develop outputs generated by the system perform aggregation, arithmetic, and logical analyses.

The level of authority delegated to this computer is minimal being limited to retrieval and error check review.

When beginning system development this management established two major priorities:

1. To establish a profitable operation.
2. To evaluate the effectiveness of alternative marketing programs and the potential associated with selected market segments.

These concerns were manifest in the measures specified for this system which emphasized profitability and market response. A few examples may help to illustrate some aspects of this system's impact on management thinking.

Figure 4 illustrates a channel analysis report developed by the sales

manager to provide a summary of product sales through particular outlets. The report illustrated covers the first six months of 1962. The company's concern with effectiveness evaluation is manifest in the use of trade margins to generate estimates of the dollar gross margin obtained from each outlet in addition to dollar and unit sales.

Since the system processes orders through all channels and, in addition, handles all warranty cards returned by purchasers the sales manager was able to implement a simple algorithm to estimate the movement of goods through each distributor. The resulting estimate of existing inventory in each outlet is indicative of the value of an integrated data file.

Management concern with market structure and composition is illustrated by the direct sales analysis report presented in Figure 5. This report provides a percentage breakdown of sales to consumers, secondary schools, colleges, business, government, and foreign purchasers during the month of May 1962 for four of the company's products.

More detailed information regarding the composition of the market was obtained through analysis of information gained from warranty cards returned to the company by purchasers of their products. As an example of the data obtained from this source, Figure 6 provides a sample warranty analysis for a single product based on warranties received during the first five months of 1962. This report summarizes the number of units sold to each of five age groups and indicates the percentage of product sales accounted for by each of these groups.

In examining Figure 6 it is important to remember that the information contained in this analysis was included in the consumer file as a descriptive characteristic of consumers who had purchased the product in question and returned their warranty card with relevant questions answered. Thus, at a later point in time, when the company was ready to market a new product believed to have substantial appeal to 15 to 18 year olds, the information which

had gone into this report was available in the data file as a basis for a selective mailing to those consumers who were within the appropriate age group.

Our examples thus far have focused on analyses of sales and consumer characteristics but have not taken advantage of the media response information generated in the course of normal processing of inquiries resulting from advertising.

Figure 7 illustrates one type of analysis relating to the performance of a variety of media employed experimentally during the fourth quarter of 1961. This report indicates the number of inquiries and sales generated by each advertisement and publicity release appearing in the indicated media during the specified period. Advertisements appearing later than December 5, 1961, are not included in the analysis. This report was made possible through coding of advertisements using keyed addresses, and tracing ultimate sales to original inquiries by means of the information retrieval system. The data file facilitated matching consumer names and addresses from orders and/or warranty cards to original names and addresses on information requests attributable to specific advertisements.

Figure 8 provides a summary of the advertisements contained in Figure 7 ordered by cost per order produced. I believe that the usefulness of this type of data presentation is self-evident. However, Figure 8 also illustrates a potential problem. Had management simply specified a listing of media by cost per order without including cost or performance data they might have concluded that media producing no orders were among the best performers. The problem illustrated is, of course, a simple result of the computer's handling of division by 0. However, it is indicative of a class of problems which arises when management accepts "answers" without understanding their basis in data.

An On-Line Management Information System

The term "on-line" relates to systems in which direct man-machine communication is made possible by the use of remote access consoles through which manage-

ment may interrogate or, given appropriate programs, interact with the computer. The point of origin device is generally a teletype or comparable typewriter based machine, however, in some more recent systems, video display consoles utilizing a television like display unit in lieu of paper output have been employed. The use of television displays of the type illustrated in Figure 9 facilitate the rapid presentation of extensive displays. In most instances the manager using a display unit of this type has the option of obtaining hard copy through ancellary printers.

The on-line system may directly parallel the off-line or batch process system with the remote access console serving the same function as the card reader or input tape unit in the batch system -- communicating to the computer the desired report format and source references. With theintroduction of direct access the problem of communication language must be considered. The language problem is obviated in batch processing since clerical personnel code requests for card input. It is, of course, possible to continue using the card code structure on-line. The manager requesting information must then type onto his console the same information punched in the batch process request card. Since card codes are designed to be economically communicated and directly read by the machine this coding procedure requires that the manager work in terms of numeric code structures. While not an impossible requirement, this type of communication can be very frustrating.

Simpler communication is frequently achieved through the use of control words or function keys. In this case the manager uses a function specifier such as CHART, DISPLAY, or CALCULATE to indicate the action to be taken by the machine or presses a "function" key which generates the desired process code. The function specifier is then followed, usually in relatively strict format, by a series of nouns and adjectives indicating the data source on which the desired report is to be based. The statement "DISPLAY BRAND X SALES, 6/1/61 - 12/31/61, DOLLARS, UNITS, MONTHLY" is representative of this type of request.

From the executive's point of view, the easiest form of communication is achieved when the machine can be programmed to accept "free form English language requests". The language is never totally free form in that the machine has a limited vocabulary -- it is assumed that the person communicating with it will limit himself to a pre-determined set of topics. In the absence of strict formatting there is a danger of ambiguity leading to misunderstandings between manager and computer. However, proper preparation of report formats insures that the manager is made aware of that which the computer thought he wanted. If the report content indicates that the computer is "confused" the manager restates his request using a different word order or more explicit statement. With experience, the manager learns to avoid ambiguous expressions. In the interest of efficiency he is apt to develop the habit of communicating with the machine in relatively strict format despite the "free form" capability.

The output illustrated in Figure 10 was obtained via an on-line console (in this case a teletype machine) interrogating the retrieval system described above modified by the addition of on-line interrogation capability. In this instance the manager has typed the request, "REPORT DISTRIBUTOR ACTIVITY FROM SEPTEMBER 1965 THROUGH OCTOBER 1965".

The computer has interpreted the word "ACTIVITY" to mean "sales and estimated profit". This definition is consistent with management's emphasis on providing profit computations whenever sales figures are given.

Figure 11 illustrates a second request and the corresponding computer response which demonstrates another aspect of system design. Although not evident to the reader unfamiliar with file content the interrogation requesting "company" information in fact provided data applicable to only one region of the firm's operations and a limited portion of the product line. Through the use of a password convention the system had previously established the identity of the inquiring individual. The information displayed in response to the word "COMPANY" was at the highest level of aggregation to which this individual

had access on the basis of pre-determined priorities. In this instance the figures relate to the regional level for those product lines which are the legitimate concern of the individual originating the inquiry. This type of security control insures that each individual using the system will have access only to data which is relevant to him. Through the use of aggregation structures which interpret limiting words such as "company" in context of a need-to-know hierarchy the system designer may insure that, once correctly identified by the computer, the president making a request for "value of company inventory" will receive actual balance sheet figures while the custodian making a similar inquiry will be given the value of janitorial supplies on stock.

A Monitor System

Without expanding the system's capability measured in terms of the first three dimensions of evaluation management may elect to grant additional authority to the computer by developing programs which enable it to monitor the content of all accessed files. In taking this step management is delegating to the computer authority for review and referral. The information system is used to implement a policy of management by exception with the computer directed to review all relevant data and refer to management only those situations which meet previously established criteria.

Installation of a monitor system introduces a new class of management problems. Policies must be formulated for computer implementation. Vague descriptions of "the sort of situation we're looking for" must be reduced to explicit definitions of that which will constitute an exception appropriate for referral. These specifications must indicate the data to be reviewed, frequency of review, and criteria of selection.

Figure 12 illustrates one type of monitor report obtained by adding monitor capabilities to the retrieval system considered earlier. This report indicates that the computer has encountered a situation in which a statistically significant, adverse sales trend has been established in one outlet of a particular distribu-

tion channel class while other outlets in that same class are showing a favorable trend.

The Advisor Function

If management is willing to go beyond the specification of criteria for referral and establish procedures to be followed when specific situations are encountered (e.g., write a letter, schedule a salesman call) the computer may be programmed to recommend an appropriate course of action. System expansion to encompass this function implies movement along two of the previously specified dimensions. Additional authority must be delegated to the computer system and, in most instances, more complex analytical programs must be developed and tested. The implications of alternative policies are frequently examined by using historical data to establish the recommendations which would have been generation had each policy been implemented during a past time period.

The Decision Function -- Direct Computer Action

Once management gains sufficient confidence in the quality of computer based recommendations they may extend the authority granted the computer one step further along the delegation dimension illustrated in Figure 2. The computer may be permitted to take the recommended action (e.g., write the letter or send the order) subject to intermittent review by supervisory personnel.

From a systems standpoint, differences between the advisory and decision making functions are small -- it is as easy to program the computer to write a letter as to generate a report indicating that a letter should be written. However, from management's point of view the relative impact of the computer is greatly increased once it is given the authority to act on behalf of the company. There is great solace in knowing that someone with whom we share human sensitivities is going to determine whether or not action should be taken. Management has an at-times justified fear of what an unattended computer might do if left to its own resources.

Successful implementation of decision systems is a result of management understanding of the procedures controlling the computer's action and careful specification of the precise level of authority granted the computer -- the specific situations in which it is permitted to take particular actions. In some situations management requires approval by supervisory personnel of computer based actions involving a commitment of resources above a certain level or the generation of communication beyond a specified point. In all instances management establishes orderly review procedures to be followed as part of a continuing assessment of computer based actions. Just as policies implemented by human subordinates are reviewed to determine their continuing applicability it is necessary to insure that models governing computer actions continue to be applicable to changing market conditions.

Learning Through Simulated Experience

Given access to a detailed disaggregated data file and a flexible program structure, management is able to test the effect of alternative analytical approaches under historical conditions -- to determine what would have happened if a particular decision procedure had been employed during the period of simulation.

In simulating past conditions, the computer at the point of decision, has no more information than it would have had were it making its decision at that moment in the then existing environment. Data following the point of decision are totally unavailable and the system must function on the basis of analyses of conditions existing at the decision time and historical records of conditions which prevailed prior to that time. As the computer moves through simulated time, information becomes available only when it enters the simulated time period when the information was generated. Through this process, years of hypothetical operating experience may be simulated in a few months of research. Following extensive testing of alternative criteria the decision procedures which yield the highest performance in terms of previously defined measures are implemented in the operating system.

Real Time Data Acquisition

The concept of real time process control is not new. It normally involves a situation in which some aspect of the production process is to be monitored to determine whether or not specified conditions are being met; evaluated to determine whether corrective action is required; and, when required, modified to establish the desired conditions. Figure 13 illustrates a typical man-based real time process control system. A meter is used to sense the thickness of the material coming from between the rollers. The man watches the meter. As the man notes a deviation away from the desired thickness he turns the wheel to adjust the roller positions, the meter returns to the desired position and the material is produced in the desired thickness. The basic elements of this system are:

1. A means of sensing the environment.
2. A conditional referral procedure.
3. A feed-back mechanism permitting the environment to be changed.

Computerization of the process described above is a relatively common phenomenon. The man at the wheel is replaced by a computer which senses the environment and automatically makes adjustment to maintain desired thickness. In most instances the man who previously turned the wheel is then upgraded from operator third class to operator first class (automatic systems specialist) and given responsibility for insuring that the computer's ON indicator remains lighted as illustrated in Figure 14.

The development of real time information systems has not been quite so simple. Although the basic concepts of real time process control are, at first blush, applicable to information system design, conditions motivating real time management information acquisition are not always clear.

At the present time managers are faced with hardware capabilities which greatly simplify real time access. Rapid data acquisition has improved the quality of airline reservation services, inventory control, and environmental surveillance systems. There is, however, a natural temptation aggravated by

where there is no need for real time data acquisition. Movement in the direction of real-time processing, is along the information recency dimension of Figure 1 in the direction of shorter time lags between event occurrence and system notification of the event. More rapid file updating is not necessarily harmful. However, the emphasis on recency created by the real time capability can cause management to give undue attention to recent events while ignoring more significant long term trends. It is ridiculous for a management to be concerned, for example, if sales in a particular region between 10 o'clock this morning and 2 o'clock this afternoon are off by 5% from sales during the same period last week.

Simulation-Based Information Systems

Systems discussed in the preceding sections have, for the most part, been based on relatively simple arithmetic or statistical models relating limited data from the market place to a single dependent performance measure. Since the planning and implementation of marketing programs involves the coordination of many types of management activity information systems have been designed to make use of micro-analytic behavioral simulations of the market environment. Two characteristics of the marketing decision structure strongly motivate the use of simulation based systems.

1. Controlling conditions in the market are a function of complex human behavior and responses.
2. Management must influence actions and responses in the market through persuasion since they are unable to exert direct control.

Management information systems based on micro-analytic market simulation generally focus on the processes through which management attempts to influence behavior in the market. The models on which such systems are based encompass detailed representations of retailer, distributor, salesmen, and consumer and industrial purchaser behavior as well as competitive interactions in the environment external to the firm.

The data files associated with these information systems encompass measures of the extent and nature of inputs to the market environment generated by the company and its competitors. The objectives in developing a simulation based information system are to achieve an artificial (model based) environment structured to accept inputs of the type monitored by the information system, and to generate outputs comparable to those obtained from the real world environment.

Figure 15 illustrates the structure of a simulation based information system. Inputs from the market environment are reviewed and formatted by a pre-processor system before being transferred to the master data file. The data file serves as the reference source for the information system and provides the historical data base for simulation model initialization.

Management has the ability to interrogate the data file directly and obtain responses following procedures comparable to those associated with the basic retrieval system discussed earlier. This set of interactions is noted by A in Figure 14.

Management's use of the simulation model as a basis for testing proposed programs is illustrated by the interaction set indicated by B . Proposed plans are inputted to the information system which establishes hypothetical conditions for runs of the simulation model. Results obtained in the simulated environment are transferred to the information system which formats them for presentation to management. Following this process management is able to evaluate the conditional results of proposed programs using the same procedures and equipment employed to assess the current state of the market through traditional interrogation.

Once a program has been finalized the proposed plan is established as a reference and simulated measures based on the plan are generated for use by the monitor sector of the information system. As the plans are implemented i n the market environment actual measures of market performance are compared with

simulated measures indicating the expected results of planned implementation. Significant deviation from plans becomes the criteria for monitor referral to management as indicated by C in Figure 14. The information system may be used to evaluate the results of research activities as well as operating plans, as indicated by D .

Development of a micro-analytic simulation involves procedures comparable to those followed when developing less complex models. However, due to the structural detail the extent of management involvement required in order to achieve the pre-conditions of successful system implementation are greatly increased. Model development begins with management definition of system scope and the objectives to be achieved through system use. Initial specifications establish boundary definitions for the simulated environment. As the development process continues increasingly detailed descriptions of behavior within key sectors of the environment and interactions between sectors are established. Models are designed to facilitate simulated generation of measures referencing key backlogs, delays, and transfer points at which the rate of product, information, or value flow may be monitored. Key decision and response elements are identified and factors influencing these processes are delineated. Hypothesized relationships between inputs and observable behavior are formulated in terms of measurements which permit validation of the model against data from the real world. Once validated at the function level, decision and response formulations are combined in a simulation structure encompassing artificial populations exhibiting actions and responses covered by these formulations.

The behavior of population groups within each simulation sector is described by accumulating simulated individual behavior. Population behavior may be summarized in terms of the proportion of purchases allotted to each brand (brand shares), changes in population attitude distributions towards brands or any other measures encompassed by the real-world information system.

Once the simulation models have been validated to management's satisfaction the simulation structure may be used to produce outputs over time comparable to those received as input from the real world market environment. As an example, Figure 16 illustrates the weekly purchases of ten drugs by one hundred members of an artificial doctor population during the simulated year, 1961. These simulated market shares may be directly compared against prescription data received by the information system as inputs from the real world environment during the comparable period.

Summary

This paper has examined characteristics of successful management information systems in use by operating and policy managers concerned with the marketing function. It has focused on attributes and impact of representative systems and characteristics of the managers responsible for their implementation. Four dimensions of information systems evaluation have been suggested: (1) information recency, (2) level of information aggregation, (3) analytic sophistication, and (4) degree of computer authority. Representative systems performing retrieval, monitor, advisory, and decision functions have been examined in the context of this dimensional framework. Management implications of on-line, real-time, and micro-analytic simulation based system structures have also been discussed.

Figure 1

BASES OF SYSTEM EVALUATION

DIMENSIONS 1 and 2

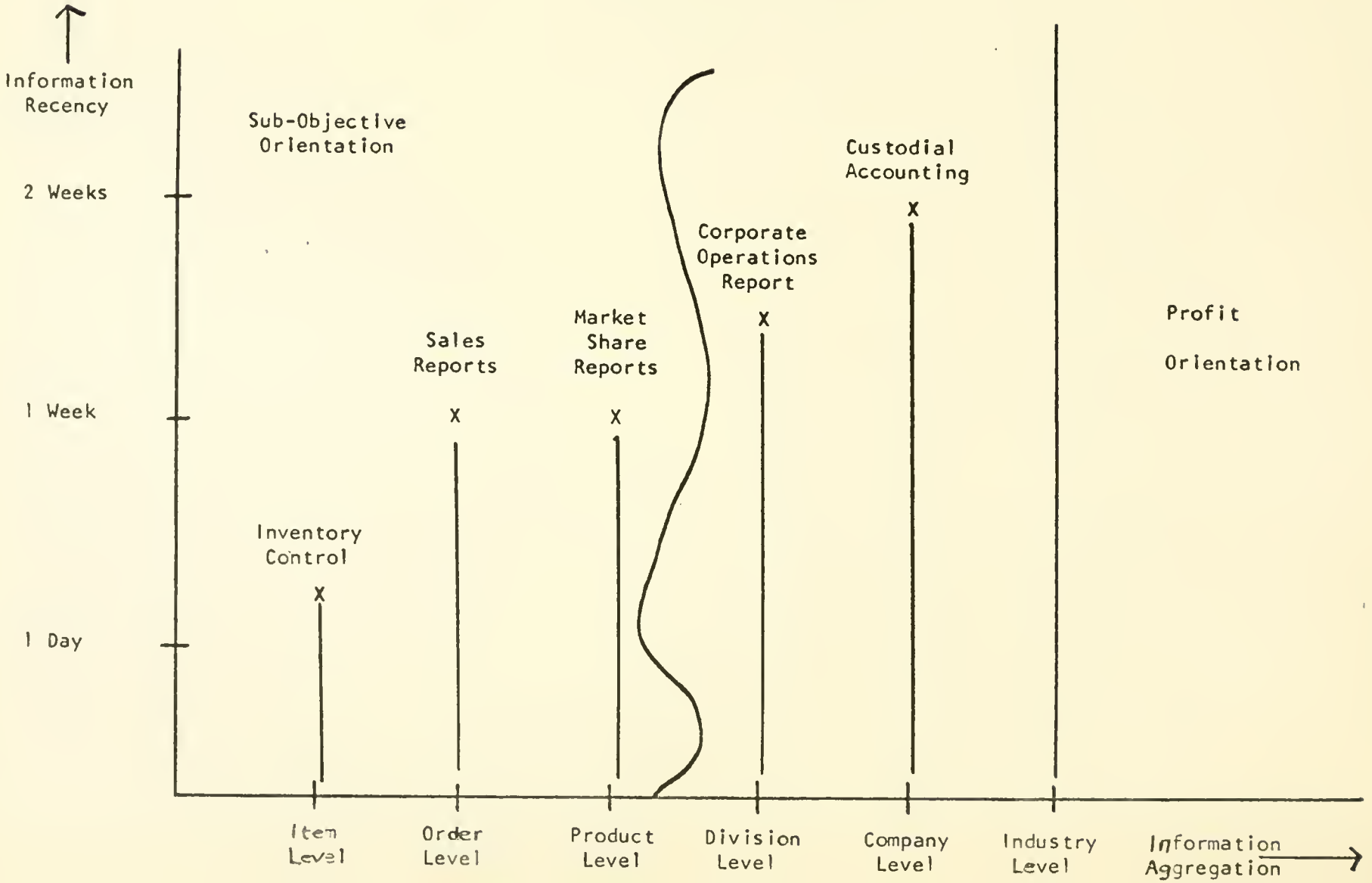


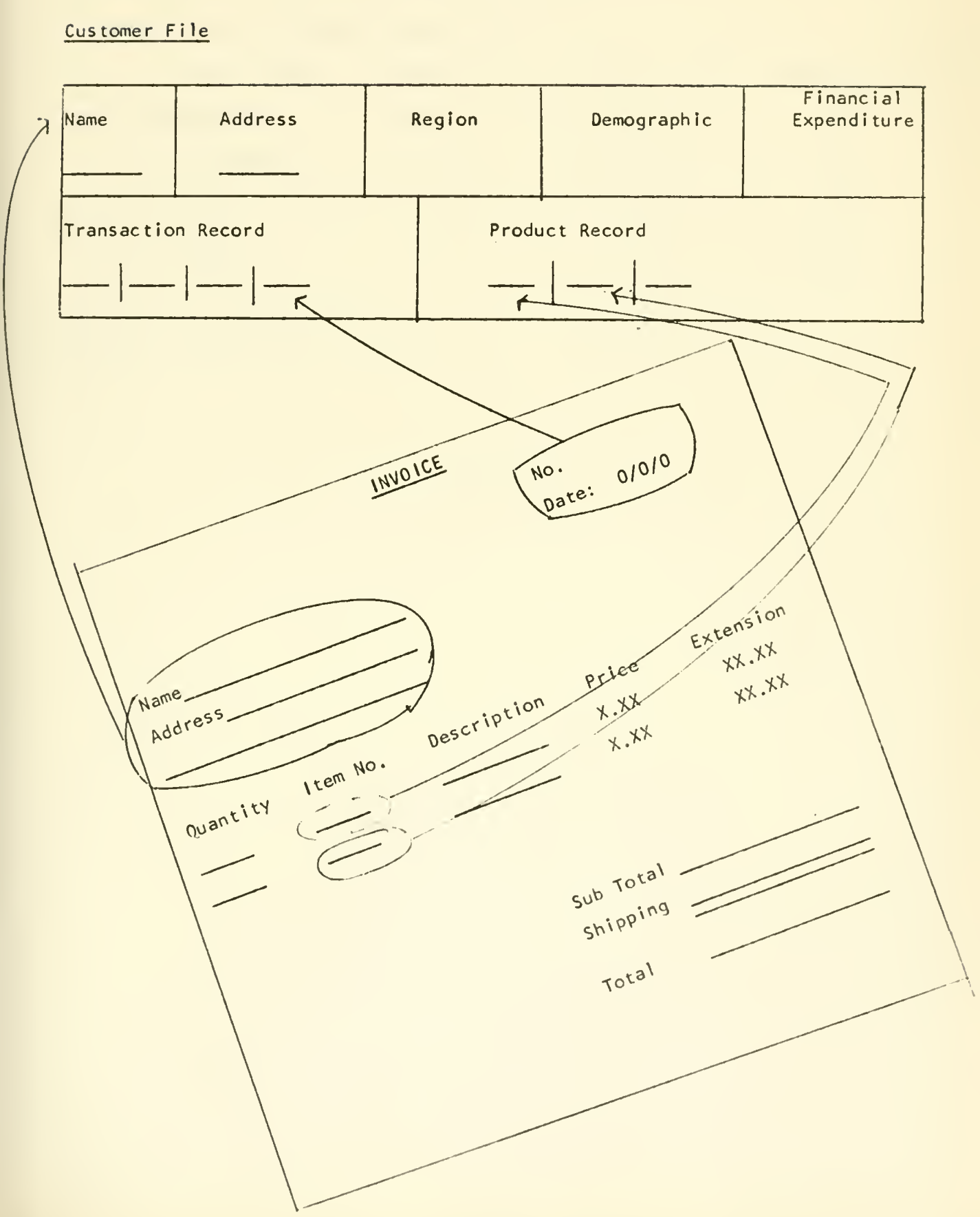
Figure 2

BASES OF SYSTEM EVALUATION

DIMENSIONS 3 and 4

Figure 3

DISAGGREGATED DATA FILE



CHANNEL ANALYSIS REPØRT

CHANNEL CLASS -- ELECTRØNIC SUPPLY - [redacted]

DATES CØVERED - 01/01/62 THRØUGH 06/31/62

TØTAL SALES FØR PERIØD	UNITS	DØLLARS	EST. INVENTØRY UNITS
-MIN[redacted]	158	9,756.50	32.
-MIN[redacted]	26	2,619.50	8.
-MAN[redacted]	12	72.00	0.0
-C/R [redacted]	19	304.00	25.
TØTAL SALES TØ THIS CHANNEL		12,752.00	
ESTIMATED CHANNEL GRØSS MARGIN		6,883.00	

Figure 4

LES DISTRIBUTIØN ANALYSIS -- DIRECT SALES -- PERCENTAGE BREAKDØWN

RIØD CØVERED -- 05/01/62 THROUGH 05/31/62

	CØNSUMER	SECØNDARY	CØLLEGES	BUSINESS	GØVERNMENT	FØREIGN
-MIN[redacted]	48.0	18.0	8.0	9.0	7.0	10.0
-MIN[redacted]	14.0	30.0	22.0	24.0	9.0	1.0
-C/F[redacted]	51.0	6.0	10.0	18.0	3.0	12.0
-MAN[redacted]	12.0	0.0	9.0	3.0	3.0	73.0

Figure 5

WARRANTY ANALYSIS -- UNIT / PERCENTAGE BREAKDOWN

PERIOD COVERED -- 01/01/62 THROUGH 05/31/62

PRODUCT -- [redacted]

AGE	UNITS	PERCENT
15 - 18	129	16.9
19 - 25	72	9.4
26 - 35	78	10.2
36 - 45	246	32.2
46 -	239	31.2

Figure 6

CHRØNØLØGICAL MEDIA ANALYSIS

DATES CØVERED - 09/01/61 THRØUGH 01/01/62

REPØRT DATE -- 01/07/62

MEDIA CUT ØFF DATE -- 12/05/61

MEDIUM	INQUIRIES	MEDIA CØST	CØST PER -INQUIRY	ØRDERS	CØST PER - SALE
BUSINESS WEEK-PR1	421.00	0.0	0.0	252.00	0.0
ELECTRØNICS ILL.	316.00	825.00	2.61	36.00	22.92
PØP. ELECTRØNICS-1	1167.00	1640.00	1.41	91.00	18.02
E.O.P. WEEKLY-PR1	4.00	0.0	0.0	0.0	0.0
PØPULAR SCIENCE-1	1874.00	3445.00	1.84	123.00	28.01
FØRTUNE - PR1	32.00	0.0	0.0	20.00	0.0
SCIENTIFIC AMERICAN-1	496.00	2310.00	4.66	77.00	30.00
ELECTRØNIC NEWS	92.00	330.00	3.59	0.0	0.0
ABSTRACT - PR1	5.00	0.0	0.0	5.0	0.0
SCIENCE WØRLD	396.00	1350.00	3.41	16.00	84.38
WALL ST. JØURNAL - 1	255.00	880.00	3.45	50.00	17.60
ELECTRØNIC WØRLD	1337.00	1495.00	1.12	55.00	27.18
PØP. ELECTRØNICS-2	1112.00	1640.00	1.47	48.00	34.17
NEW YØRK TIMES - 1	2057.00	3090.00	1.50	191.00	16.18
SCIENCE NEWS LETTER-1	310.00	430.00	1.39	93.00	4.62
PØPULAR SCIENCE - 2	2220.00	3445.00	1.55	104.00	33.13
SCIENTIFIC AMERICAN-2	1244.00	2310.00	1.86	213.00	10.85
SCIENCE NEWS LETTER-2	155.00	430.00	2.77	29.00	14.83
TECHNØLØGY REVIEW-PR1	6.00	0.0	0.0	4.00	0.0
AUTØMATIØN	166.00	500.00	3.01	13.00	38.46
SATURDAY REVIEW	61.00	777.00	12.74	0.0	0.0
SCIENCE NEWS LETTER-3	126.00	430.00	3.41	13.00	33.08
PØP. ELECTRØNICS - 3	2873.00	1640.00	.57	97.00	16.91
SCIENCE NEWS LETTER-4	65.00	430.00	6.62	13.00	33.08
PØP. ELECTRØNICS - 4	758.00	1640.00	2.16	11.00	149.09
MATHEMATICS TEACHER	95.00	250.00	2.63	6.00	41.67
DATAMATIØN	445.00	460.00	1.03	6.00	76.67
WALL ST. JØURNAL - 2	98.00	608.00	6.20	22.00	27.64
EL. DESIGN NEWS	289.00	350.00	1.21	11.00	31.82
NEW YØRK TIMES - 2	2940.00	3090.00	1.05	213.00	14.51
NEW YØRK TIMES - 3	2092.00	1989.00	.95	136.00	14.63
ELECTRØNICS PRØDUCTS	26.00	285.00	10.96	4.00	71.25
RADIØ ELECTRØNICS	36.00	340.00	9.44	0.0	0.0
INDUSTRIAL RESEARCH	90.00	410.00	4.56	9.00	45.56
FLEET ØWNER - PR1	91.00	0.0	0.0	2.00	0.0
MADISØN AVENUE - PR1	3.00	0.0	0.0	0.0	0.0
BUSINESS AUTØMATIØN	71.00	360.00	5.07	0.0	0.0
NEW YØRK TIMES - 4	25.00	164.00	6.56	2.00	82.00
WALL ST. JØURNAL - 3	125.00	385.00	3.08	4.00	96.25
SCIENCE NEWS LETTER-5	17.00	90.00	5.29	2.00	45.00
BUSINESS WEEK	93.00	835.00	8.98	4.00	208.75
SCIENCE	17.00	230.00	13.53	2.00	115.00

Figure 7

MEDIA ANALYSIS--COST PER SALE

DATES COVERED - 09/01/61 THROUGH 01/01/62

REPORT DATE -- 01/07/62

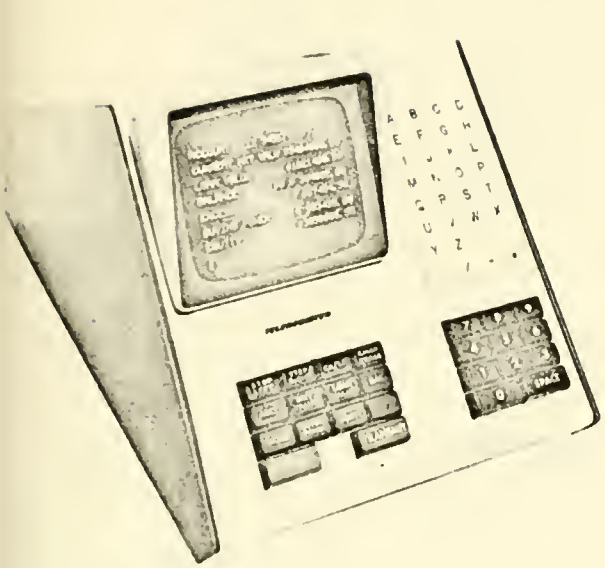
MEDIA CUT OFF DATE -- 12/05/61

MEDIUM	INQUIRIES	MEDIA COST	COST PER -INQUIRY	ORDERS	COST PER - SALE
BUSINESS AUTOMATION	71.00	360.00	5.07	0.0	0.0
ELECTRONIC NEWS	92.00	330.00	3.59	0.0	0.0
RADIO ELECTRONICS	36.00	340.00	9.44	0.0	0.0
SATURDAY REVIEW	61.00	777.00	12.74	0.0	0.0
SCIENCE NEWS LETTER-1	310.00	430.00	1.39	93.00	4.62
SCIENTIFIC AMERICAN-2	1244.00	2310.00	1.86	213.00	10.85
NEW YORK TIMES - 2	2940.00	3090.00	1.05	213.00	14.51
NEW YORK TIMES - 3	2092.00	1989.00	.95	136.00	14.63
SCIENCE NEWS LETTER-2	155.00	430.00	2.77	29.00	14.83
NEW YORK TIMES - 1	2057.00	3090.00	1.50	191.00	16.18
POP. ELECTRONICS - 3	2873.00	1640.00	.57	97.00	16.91
WALL ST. JOURNAL - 1	255.00	880.00	3.45	50.00	17.60
POP. ELECTRONICS-1	1167.00	1640.00	1.41	91.00	18.02
ELECTRONICS ILL.	316.00	825.00	2.61	36.00	22.92
ELECTRONIC WORLD	1337.00	1495.00	1.12	55.00	27.18
WALL ST. JOURNAL - 2	98.00	608.00	6.20	22.00	27.64
POPULAR SCIENCE-1	1874.00	3445.00	1.84	123.00	28.01
SCIENTIFIC AMERICAN-1	496.00	2310.00	4.66	77.00	30.00
EL. DESIGN NEWS	289.00	350.00	1.21	11.00	31.82
SCIENCE NEWS LETTER-3	126.00	430.00	3.41	13.00	33.08
SCIENCE NEWS LETTER-4	65.00	430.00	6.62	13.00	33.08
POPULAR SCIENCE - 2	2220.00	3445.00	1.55	104.00	33.13
POP. ELECTRONICS-2	1112.00	1640.00	1.47	48.00	34.17
AUTOMATION	166.00	500.00	3.01	13.00	38.46
MATHEMATICS TEACHER	95.00	250.00	2.63	6.00	41.67
SCIENCE NEWS LETTER-5	17.00	90.00	5.29	2.00	45.00
INDUSTRIAL RESEARCH	90.00	410.00	4.56	9.00	45.56
ELECTRONICS PRODUCTS	26.00	285.00	10.96	4.00	71.25
DATAMATION	445.00	460.00	1.03	6.00	76.67
NEW YORK TIMES - 4	25.00	164.00	6.56	2.00	82.00
SCIENCE WORLD	396.00	1350.00	3.41	16.00	84.38
WALL ST. JOURNAL - 3	125.00	385.00	3.08	4.00	96.25
SCIENCE	17.00	230.00	13.53	2.00	115.00
POP. ELECTRONICS - 4	758.00	1640.00	2.16	11.00	149.09
BUSINESS WEEK	93.00	835.00	8.98	4.00	208.75

Figure 8

Figure 9

VIDEO DISPLAY UNITS



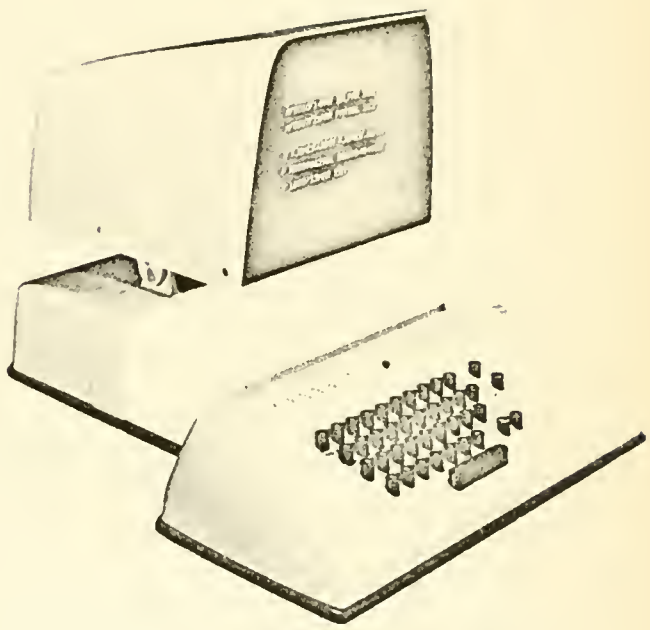


Figure 10

ON-LINE OUTPUT -- EXAMPLE 1

```
REPORT DISTRIBUTOR ACTIVITY FROM SEPT 1965 THRU OCTOBER 1965
 SALES AND ESTIMATED PROFIT
   SEP
DISTRIBUTOR 1   1170.53    399.95
DISTRIBUTOR 2    649.63    238.77
DISTRIBUTOR 3    755.08    284.51
DISTRIBUTOR 4   1066.97    348.56
DISTRIBUTOR 5    541.01    197.43
   OCT
DISTRIBUTOR 1    990.63    327.04
DISTRIBUTOR 2    567.18    186.53
DISTRIBUTOR 3    707.95    218.86
DISTRIBUTOR 4    850.51    297.83
DISTRIBUTOR 5    520.11    189.10
READY
```

Figure 11

ON-LINE OUTPUT -- EXAMPLE 2

```
READY
REPORT COMPANY QUARTERLY SALES, PROFIT FROM FIRST 1965 THRU THIRD 1965
                SALES   GROSS PROFIT
 QUARTER 1

 QUARTER 2    149660.55      34184.92

 QUARTER 3    114589.05      28875.66

              73799.81       21130.12
READY
```

Figure 12

SAMPLE MONITOR OUTPUT

MONITOR REPORT

PRODUCT - [redacted]

BASIS - DOLLAR SALES TREND

DATES COVERED - 01/01/64 - 0/08/64

CHANNEL - ELECTRONIC SUPPLY.

OUTLET - [redacted]

AVG. CHANNEL SALES	800.	PROFIT	250.	TREND	+46.
THIS OUTLET	210.		62.		-34.

Figure 13

REAL TIME PROCESS CONTROL

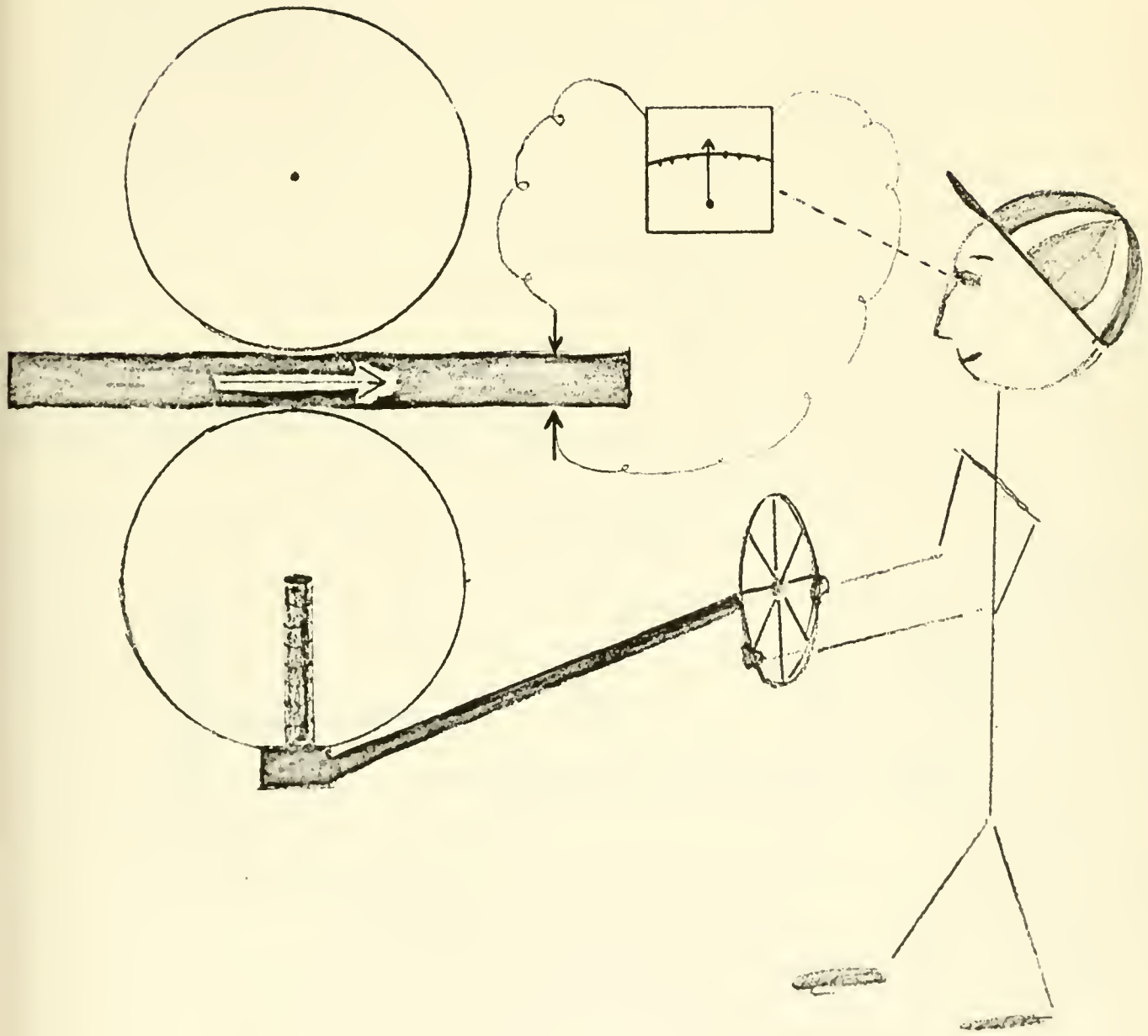
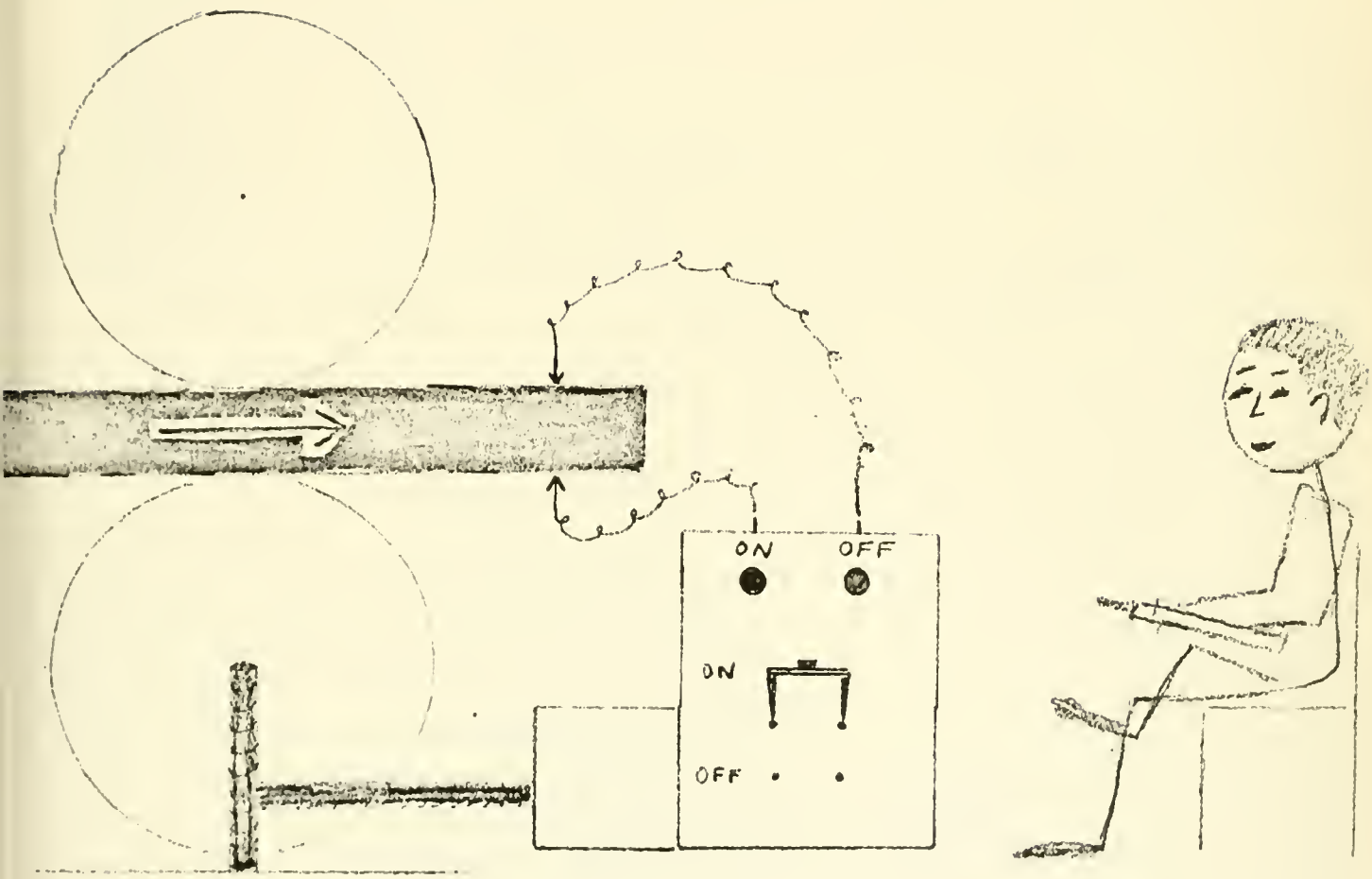


Figure 14

MACHINE AIDED REAL TIME PROCESS CONTROL



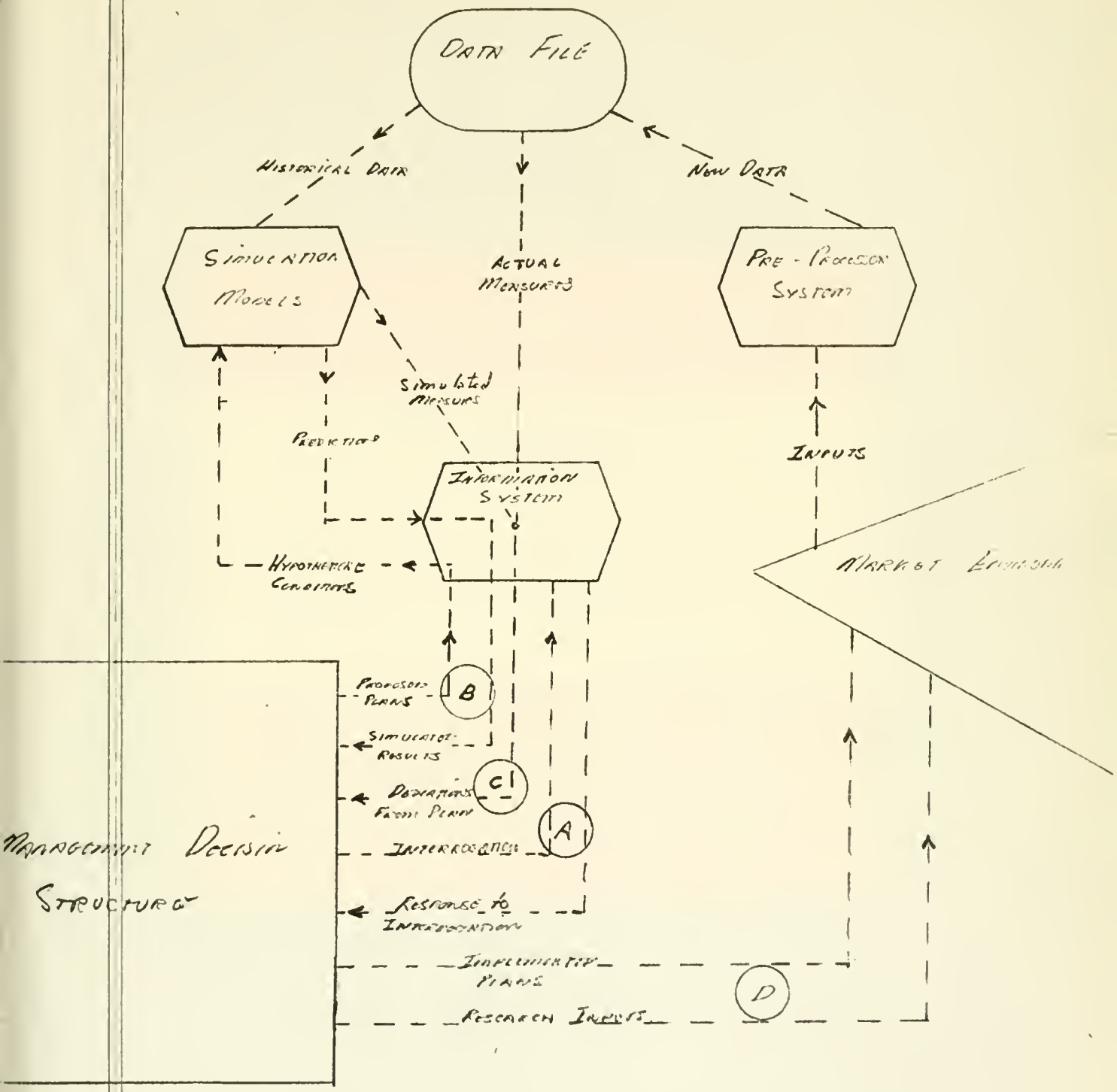


FIGURE 15 -- SIMULATION BASED SYSTEM STRUCTURE

Date Due

DEC 11 '75
DEC 22 '75
JAN 20 '76
FEB 18 '76
DEC 27 '76
MAY 21 '78
SEP 1 '78
MAY 25 '79
MAY 21 '82

Lib-26-67

211-66

1752284

HD28 M.I.T. Alfred P. Sloan
.M414 School of Management
Nos.211-66-Working Papers.
Nos.224-66 Nos.211-66 to Nos.224-66

3 9080 003 869 895

3 9080 003 869 614

212-66

3 9080 003 869 713

213-66

BASEMENT

3 9080 003 900 856

214-66

SIGN this card and present it with book
at the CIRCULATION DESK.

3 9080 003 900 633

215-66

MASSACHUSETTS INSTITUTE OF
TECHNOLOGY LIBRARIES

3 9080 003 870 240

216-66

DEWEY LIBRARY

3 9080 003 901 300

217-66

218-66

3 9080 003 901 284

3 9080 003 870 307

224-66

3 9080 003 901 268

211-66

3 9080 003 870 281

222-66

3 9080 003 870 265

223-66